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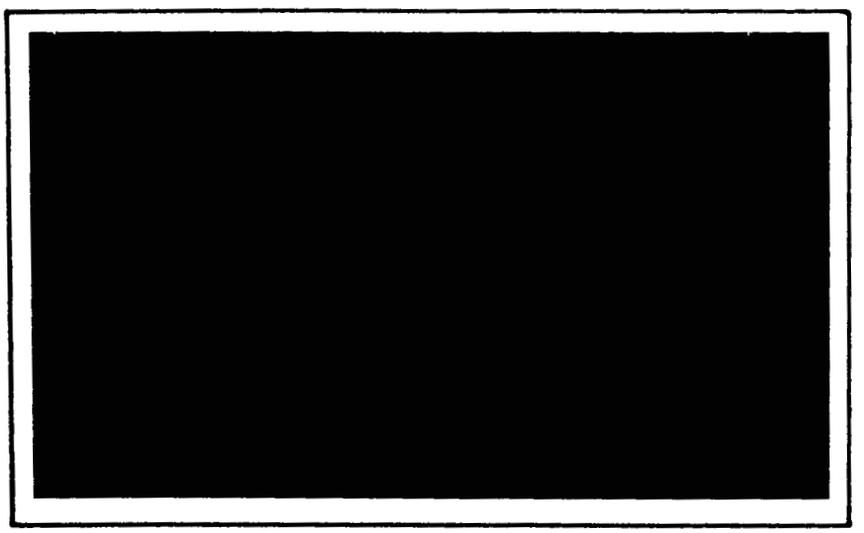

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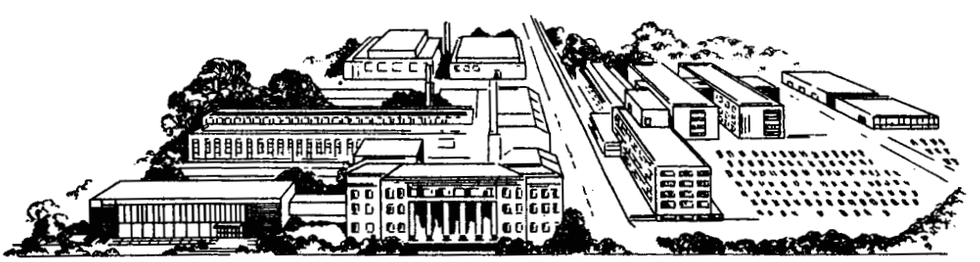

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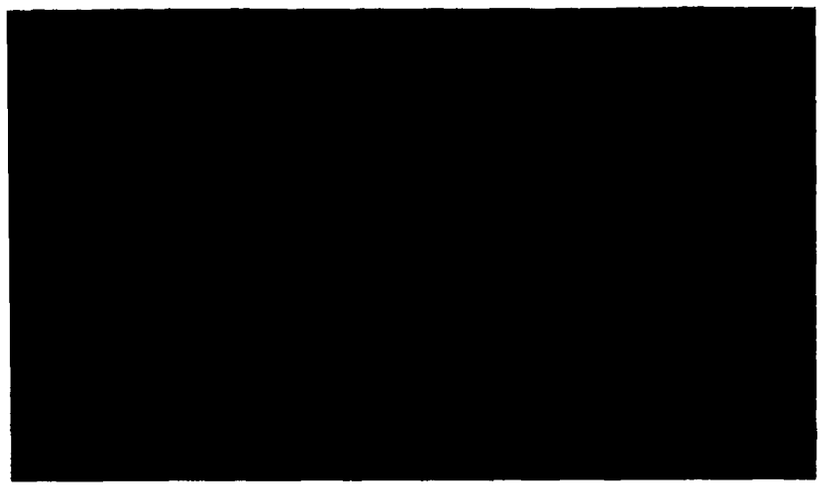

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SEVENTH QUARTERLY REPORT

on

A STUDY OF THE RELIABILITY OF ELECTRONIC COMPONENTS IN A NUCLEAR-RADIATION ENVIRONMENT

to

JET PROPULSION LABORATORY

October 13, 1964

by

C. L. Hanks and D. J. Hamman

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration under Contract NAS7-100.

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October 13, 1964

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California

Attention Mr. J. Michael Whalen
Contract Negotiator

Gentlemen:

This is the Seventh Quarterly Progress Report and the Twenty-second Monthly Progress Report on Contract No. 950458 (File 2998) entitled "A Study of the Reliability of Electronic Components in a Nuclear-Radiation Environment". The period covered is from July 1 to September 30, 1964.

Progress during this report period has included the completion of postirradiation and/or preoperational life test measurements at room ambient and test temperature on the parts in the 100° C, high-flux capsule (Test Group IV) and initial or preirradiation measurements on the component parts in Test Groups I, II, III, and V. In addition, 144 hours of radiation exposure was completed on the electronic parts in the two 10,000-hour, low-flux capsules (Test Groups III and IV) with a similar period of operational life on the other three test groups.

Very truly yours,

Carl L Hanks for D.J.H.

Donald J. Hamman
Electronic Materials and Devices Group
Engineering Physics Department

DJH:mk

Enc.

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A STUDY OF THE RELIABILITY OF ELECTRONIC COMPONENTS IN A NUCLEAR-RADIATION ENVIRONMENT

by

C. L. Hanks and D. J. Hamman

INTRODUCTION

This is the Seventh Quarterly Report and the Twenty-second Monthly Progress Report on Contract No. 950458 (File 2998) entitled "A Study of the Reliability of Electronic Components in a Nuclear-Radiation Environment". This report summarizes the project activity from July 1 to September 30, 1964, which has included the completion of the initial or 0-hour measurements of the electronic parts in Test Groups I, II, III, and V at room ambient and test temperature. The postirradiation measurements (prior to 10,000 hours of operational life) of the electronic parts in Test Group IV were also completed at room ambient and test temperature during this period.

PROGRESS SUMMARY

Progress during this report interval has included the following project activities:

1. Completion of initial or 0-hour measurements at room ambient and test temperature on component parts in Test Groups I, II, III, and V.

2. Completion of postirradiation and/or 0-hour measurements for postirradiation life test at room ambient and 100° C on component parts in Test Group IV.
3. Installation of the Fairchild Semiconductor (Instrumentation), Model 50, Digital Readout h_{FE} Tester at the Battelle Research Reactor facility.
4. Completion of 144 hours of irradiation exposure on the component parts in the 10,000-hour radiation capsules, Test Groups III and V.

TECHNICAL DETAILS

Project effort during this report interim was directed toward the completion of the initial or 0-hour measurements of the test specimens in the two 10,000-hour, low-flux, radiation capsules (Test Groups III and V) and the two control test environments (Test Groups I and II) at room ambient and test temperature. Postirradiation measurements of the parts in the 100-hour, high-flux capsule (Test Group IV) at room ambient and test temperature were also a part of this effort. In addition, the ion gages that monitor the system pressure at a point approximately 14 feet above the test sections, or capsules, were replaced with cold cathode ion gages.

This section presents various details concerning these activities and the progress that has been made.

Instrumentation

The Fairchild Semiconductor (Instrumentation), Model 50, Digital Readout h_{FE} Tester that was obtained during the preceding report interval was installed at the Battelle Research Reactor facility during this interval. However, the operation of this equipment is limited to a manual entry procedure, as opposed to automatic data entry, at this time. The manual procedure includes application of the automatic data-recording system for the selection of specimens and to provide the identifying information that is required on the data card.

The relay buffer unit that is required for automatic data entry from the digital output of the h_{FE} tester was completed, but its incorporation into the data-recording system was delayed due to the lack of a connector assembly to fit the output of the tester. The assembly has been obtained from Fairchild Semiconductor (Instrumentation) and will be installed on the input wires to the relay buffer unit at the earliest opportunity.

Measurement Status of Test Groups I, II, III, and V

Initial or 0-hour measurements at room ambient and test temperature have been completed on Test Groups I, II, III, and V including pulsed d-c current gain, h_{FE}, with the Fairchild Model 50 tester. The measurements of h_{FE} previously performed at room ambient with the Battelle-constructed instrumentation were repeated with the Fairchild system for better correlation with measurements that will be performed at selected intervals throughout the test program.

Measurement Status of Test Group IV

Postirradiation and/or preoperational life test measurements at room ambient and test temperature were also completed on the electronic parts in Test Group IV. These electronic parts were previously subjected to 100 hours of nuclear radiation at a rate whereby they received the same total exposure that Test Groups III and V are expected to receive in 10,000 hours. The pulsed d-c current gain measurements at room ambient were repeated on the transistors in Test Group IV for the same reason as mentioned above for the other four test groups, better correlation or comparison with similar measurements that will be performed at specified intervals during the remainder of the test program.

Results

The electronic parts in Test Groups III and V completed 144 hours of operational life in the radiation field during this report interval. The parts in Test Groups I, II, and IV underwent a similar period of operational life outside the radiation field. For the component parts in Test Group IV, this was in addition to the 100-hour operational life, high-flux, radiation exposure to which they were subjected earlier. Observations or results during this period included difficulties in establishing the specified operating conditions for several transistor types and the catastrophic failure of 24 transistors and one capacitor.

Three transistor types show a large number of units exhibiting an inability to be stabilized at the collector currents specified for their

operation in this program, i.e., the adjustment available in the emitter-base circuit appears to be inadequate to obtain the required collector output. Initially, when power was first applied to these transistors, they were operating at the required power dissipation; but, as they experienced a temperature rise due to their internal dissipation, they gradually drifted beyond the control limits of the circuit. Therefore, by the nature of the transistor loading circuit design, as described in the first quarterly report, these transistors are actually operating below the specified stress. The transistor types that are experiencing this problem to a greater degree than the others are the 2N2297, 2N1050, and 2N914 with 72, 51, and 28 units beyond the control adjustments of the load circuits, respectively. The six remaining transistor types have been one and ten specimens that are exhibiting this same problem.

Twenty-two of the twenty-eight 2N914 transistors that are beyond the control limits of the loading circuits "shorted" within 24 hours after the test was started (see Table 1). The two 2N930 transistors that shorted at 48 hours also were beyond the control limits of their loading circuits.

One additional component part type experienced a known catastrophic failure since the start of the irradiation and operational life of control tests. This single failure was an Aerovox P322ZN Capacitor (Specimen No. 87) operating in the 10,000-hour, low-flux, 50° C radiation capsule (Test Group V) which was "shorted" after 144 hours of exposure to these test conditions.

TABLE 1. IDENTIFICATION OF CATASTROPHIC FAILURES

Type of Component	Manufacturer's Part Number	Test Group	Specimen Number	Hours at Failure	Remarks
Transistor	2N914	I	20	<24	Shorted
Transistor	2N914	I	22	<24	Shorted
Transistor	2N914	II	47	<24	Shorted
Transistor	2N914	II	48	<24	Shorted
Transistor	2N914	III	00	<24	Shorted
Transistor	2N914	III	03	<24	Shorted
Transistor	2N914	III	06	<24	Shorted
Transistor	2N914	III	08	<24	Shorted
Transistor	2N914	III	10	<24	Shorted
Transistor	2N914	III	12	<24	Shorted
Transistor	2N914	III	14	<24	Shorted
Transistor	2N914	III	16	<24	Shorted
Transistor	2N914	III	19	<24	Shorted
Transistor	2N914	IV	60	<24	Shorted
Transistor	2N914	IV	64	<24	Shorted
Transistor	2N914	IV	69	<24	Shorted
Transistor	2N914	V	80	<24	Shorted
Transistor	2N914	V	82	<24	Shorted
Transistor	2N914	V	84	<24	Shorted
Transistor	2N914	V	90	<24	Shorted
Transistor	2N914	V	92	<24	Shorted
Transistor	2N914	V	95	<24	Shorted
Transistor	2N930	II	40	48	Shorted
Transistor	2N930	II	43	48	Shorted
Capacitor	P323ZN	V	87	144	Shorted

FUTURE PLANS

The radiation exposure and operational life tests will continue throughout the next report interval. This will include the completion of almost 2000 hours of irradiation with parameter measurements of the various component parts at the 250-, 500-, and 1000-hour intervals. The 2000-hour measurement interval is expected to occur at the end of the next report period. Work will also be initiated on the additional tasks that have been proposed as soon as authorization is obtained from the Jet Propulsion Laboratory.